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☐ 1. Document ID: JP 52111891 A

L3: Entry 1 of 1 File: DWPI Sep 19, 1977

DERWENT-ACC-NO: 1977-78360Y
DERWENT-WEEK: 197744

TITLE: Metal surface treatment to increase hardness - comprises hardening base metal and depositing e.g. molybdenum film

PATENT-ASSIGNEE:

ASSIGNEE	CODE
HONDA MOTOR IND CO LTD	HOND

PRIORITY-DATA: 1976JP-0028633 (March 18, 1976)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
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INT-CL (IPC): C23C 11/00; C23C 13/00; C23C 15/00

ABSTRACTED-PUB-NO: JP 52111891A
BASIC-ABSTRACT:

Metal film is formed on the hardened surface of a base metal. Method comprises subjecting a base metal to hardening treatment and then subjecting the hardened surface of the base metal to gas phase surface treatment such as ion-plating, spattering, or TiC deposition to form a hard metal film having high m. pt. such as, Mo, W, Cr, Ni, TiC or TiN.

The hardening treatment is, for example, ion-nitriding or carbonising-nitriding. The hardness of the metal surface can be increased in a simple process.

TITLE-TERMS: METAL SURFACE TREAT INCREASE HARD COMPRISE HARDEN BASE METAL DEPOSIT MOLYBDENUM FILM

DERWENT-CLASS: M13

CPI-CODES: M13-D; M13-F; M13-G; M13-H04;

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JP 52111891 A	September 19, 1977	N/A	000	N/A

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⑲日本国特許庁

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㊾金属の表面処理方法

㉑特　　願　昭51―28633
㉒出　　願　昭51(1976) 3月18日

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明　細　書

1. 発明の名称

金属の表面処理方法

2. 特許請求の範囲

表面硬化処理可能な金属材料からなる基材表面部に表面硬化処理を施して硬化層を形成し、次いでイオンプレーテイング法，スパッタリング法，TiC被覆法等の気相表面処理法によりMo，W，Cr，Ni，TiC，TiN等の高融点硬質金属類でこの基材硬化層表面に金属被覆を形成するようにしたことを特徴とする金属の表面処理方法。

3. 発明の詳細な説明

本発明は金属の表面硬化処理後、気相表面処理を施し、金属の硬度，耐摩耗性を向上させるようにした表面処理方法に関するもので、特に比較的安価なクロムモリブデン鋼，機械構造用炭素鋼（SCM22，S45C）等の表面硬化処理可能な低級材を用い、これを浸炭窒化法，イオン窒化法等で表面硬化処理を行つた後、この素材表面をイオンプレーテイング法，スパッタリング法，TiC被覆法等の気相表面処理を施こし、高硬度で耐摩耗性を向上させた金属製品を得ることができるようにした表面処理方法に関する。

機械の高速摺動部、例えばバルブロッカーアーム，デフピニオンシヤフト等は、曲げ，捻りに強いこと等の条件を要求される他、耐熱性，耐摩耗性等の苛酷な条件に適合するものであることが要求される。

従つて前記した機械部品等を前記条件に適合させるため、従来では次の如き表面処理法を採用している。

即ち、基材表面にMo，W等の高融点金属をプラズマ溶射等で溶射する方法，電気メツキ法で基材表面に硬質クロムメツキ被覆を行う方法、或は基材に浸炭窒化法やガス軟窒化，塩浴窒化，イオン窒化等の窒化硬化法で表面硬化処理を施したものが用いられている。

このような従来手段において、前記した溶射法では後加工が頗る面倒且つ困難で、工具寿命その他でも問題を生じること、又剥離発生の可能性が

あり、剥離強度の点でも問題がある。又前記メッキ処理法では基材とメッキ層の境界部に剥離が生じ易く、且つ比較的長時間の処理を必要とし、時間経済上好ましくないこと、公害上の問題もある。更に又表面硬化処理法では一般的な条件は充足できるが、前記の如き苛酷な条件を要求される機械部品等に用いた場合、充分な耐久性を得ることが仲々困難である。

本発明者等は前記の如く機械的強度，耐熱性，耐摩耗性等の苛酷な条件を要求される機械部品等の表面処理方法における前記した如き現状，問題点に鑑み、曲げ，捻り等の機械的強度に優れ、且つ耐熱性，耐摩耗性に優れた金属製品を得るべく鋭意研究し、本発明を成したものである。

本発明者等は、イオンプレーティング法，スパッタリング法，TiC法等の気相表面処理法に着目し、これによつて表面処理を行うべく諸種研究した処、低級材の表面に直接Cr,Mo等の高融点金属をコーティングする場合、母材の強度が弱いため硬質コーティング膜を厚くしなければヘルツ応力

の高い製品に適用し難いこと、又コーティング膜を厚くすると脆性化して曲げ，捻れ，衝撃等の加わる製品には適さないこと等を勘案し、このコーティング以前に表面硬化処理を施こし、爾後前記した気相表面処理することにより、基材とコーティング膜との密着度が増加すること、機械的性質が向上し、耐熱性，耐摩耗性，耐衝撃性等が向上し、苛酷な条件にも充分に耐え得る金属材を得ることができるという知見を得て本発明を成したものである。

従つて本発明の目的とする処は、機械摺動部の如く苛酷な条件を要求される機械部品等の表面処理方法として、曲げ，捻り等の機械的強度に優れ、且つ耐熱性，耐摩耗性，耐衝撃性に優れ、前記条件を充分に満足する金属製品を得ることができる表面処理方法を提供する。

又本発明は、基材として表面硬化処理可能な素材であれば良く、例えばSCM22，S45C 等の安価な低級材を用いることができ、従つて安価な素材で前記した如き条件を充分に満足する金属製品が

得られ、以上を経済的且つ量産可能に得ることができる表面処理方法を提供することを目的とする。

以下に本発明の一実施例を添付図面に従つて詳述する。

本発明にかかる表面処理方法には表面硬化処理可能な金属材料が用いられる。この材料は表面硬化処理が可能であれば良く、従つて比較的安価な低級材、例えばSCM22，S45C 等の一般表面硬化処理材が用いられる。この材料よりなる基材 a を表面硬化処理し、表層部に硬化層 b を形成する。この表面硬化処理手段としては浸炭窒化法，イオン窒化法，塩浴窒化法，ガス軟窒化法等で行い、基材表層部の硬度を向上させて基材を強化させる。

次いで表面硬化処理を施した基材にMo,W,Cr,Ni,TiC,TiN 等の高融点硬質金属類をイオンプレーティング法，スパッタリング法、或はTiC被覆法等の気相表面処理を施し、硬化層 b の表面に耐摩耗性の金属被覆層 c を形成し、最終的に耐熱性，耐摩耗性等の前記した苛酷な条件に耐える金属材を得る。

この金属被膜層 c を形成するにさいし、表面硬化処理を予じめ行うのは、低級材にCr,Mo,W等の高融点硬質金属を直接コーティングすると、母材の強度が弱いために硬質の被膜層を相当厚く形成しなければヘルツ応力の高い製品には適用し難く、又被膜を高くすると脆性化し、曲げ、捻れ、衝撃等の加わる製品に適さない。従つてCr,Mo,W等の高融点硬質金属をコーティングするにさいし、予じめ下地金属の硬度を高め、その上に硬質の被膜層を形成させる必要がある。

以上において、下地金属である基材 a をイオン窒化，浸炭窒化等の表面硬化処理で硬度を高め、適当な温度に加熱保持しつつCr,Mo,W等の高融点硬質金属をイオンプレーティング法等の気相表面処理方法でコーティングすると、下地金属表面のC原子，N原子が微量ながら熱拡散反応によつて表面のコーティング部へ浸透し、基材とCr,Mo,Wの被膜間との密着性を増加させるとともに、被膜層の機械的性質を向上させることにより耐熱性，耐摩耗性，耐衝撃性等の苛酷な条件にも充分に耐

え得る金属材が得られた。又これ等一連の処理方法においては、下地金属の硬度が浸炭や窒化等の表面硬化処理で基材表層部の硬度が高いため、被膜形成は薄くても良い。又表面硬化処理し、且つその表面に前記被膜を形成するため、表面硬化層もこれのみによるものに比し薄くて良く、このため基材の有する靱性，曲げ，捻れ等の機械的性質を損なうことなく高硬度，耐熱，耐摩耗、且つ耐衝撃性に優れた金属材を得ることができる。

以上を第2図のグラフで説明する。グラフはテストピースをデフピニオンシャフトとし、これを乾式一増加荷重により実験し、これの測定結果を示し、各テストピースA～Dは同一条件で行い、グラフ中の線A～Dは夫々のテストピースを示している。グラフ中横軸を荷重Kg，縦軸を摩擦係数μとして示し、テストピースとして材質S48C（16ϕ×100^{L}）を用いた。

このグラフにおいてAは軟窒化硬化処理材を、Bは硬質クロムメッキ処理材を、CはMo溶射材を、Dは本発明にかかる表面硬化処理方法として

軟窒化硬化処理を施し、Moをプレーティング法でコーティングしたものを用いた。グラフで明らかな如く、Aは摩擦係数が大きく、荷重75Kg近傍で焼付を起し、BはAに比し摩擦係数は小さいが荷重90Kg近傍で焼付が発生し、Cは摩擦係数は小さいが荷重38Kg近傍でコーティング層の剥離が発生した。

しかるに本発明にかかるテストピースはDで示す如く摩擦係数が小さく、且つ荷重90Kg近傍でも焼付が発生せず、前記を実証した。

第3図及び第4図は本発明にかかる表面処理方法を実施するための具体的装置の一例を示しており、何れもイオン窒化処理により表面硬化処理を行い、更に前記の如く被膜形成を行う方法を示している。

第3図はイオン窒化処理と被膜形成処理を同一炉内で同時且つ連続的に行う実施例を示し、以下にその概略を説明する。炉1内に被処理物Wを装入し、真空ポンプ2で内部を真空にし、ガス供給手段3でH_2ガス等を導入し、この雰囲気内で金

属材料8と被処理物Wの支持体4間に直流電圧を印加し、イオンボンバーディングによつて窒化処理温度近傍まで当該被処理物Wを加熱する。又被処理物Wの支持体4に埋設された加熱体5に通電し、イオンボンバーディングと併用して加熱しても良い。次にガス供給手段3，6でH_2，N_2等のガスを適当な割合で導入し、1～10Torrのガス圧下で所定の時間イオン窒化処理を行う。このさい炉1内の上部に絶縁遮蔽体7で支持された被覆金属材料8を導電性プロテスター9で覆つて保護し、これを窒化処理時に陽極として用い、被処理物W及び支持体4のスパッタによる汚染を防止する。

イオン窒化処理後前記ガス供給手段3，6を止め、別の手段10からArガスを導入し、ガス圧10^{-3}Torr程度の雰囲気中で金属材料8に電圧を印加し、所定の時間スパッタリング溶着を行う。このさい前記プロテクター9はこれを支持する調節杆11で金属材料8から離し、プラズマ空間の妨げにならない位置に旋回等して調節される。又

被処理物Wを所定の温度に保持するために加熱体5の通電も適宜調節される。

以上はイオン窒化処理で表面硬化処理を施したが前記の如く諸種の表面硬化処理法を用い得ることは勿論で、又この処理後の気相表面処理手段で前記した如くスパッタリング法，イオンプレーティング法，TiC被覆法等適宜に選択できる。

第4図は前記した装置を分割し、連続炉とした実施例で、被処理物Wは予熱室20で窒化処理温度近傍まで予熱され、シャッター21を開いてイオン窒化処理室22内へ導き、真空ポンプ23で抜気し、H_2，N_2ガス等を供給手段24で導入し、支持体25上の被処理物Wに前記の如くイオン窒化処理を施こす。

次いでシャッター26で気密に区画されたスパッタリング室27内にこのシャッター26を開いて窒化処理完了した被処理物Wを搬入し、シャッター26を閉じて室27内を真空ポンプ28で抜気し、Arガス等を供給手段29で導入し、金属材料30に電圧を印加し、所定の時間スパッタリ

ング溶着を行う。以後シャッター31を開いて冷却室32へ両処理後の被処理物Wを送り出す。これによれば各処理を工程順に連続して行うことができ、量産化上好都合である。

以上の実施例も前記第3図の実施例と同様である。

以上の説明で明らかから如く本発明によれば、表面硬化処理可能な金属材料を、先ず表面硬化処理し、次いでスパッタリング法，イオンプレーティング法，TiC被覆法等の気相表面処理法でCr,Mo,W等の高融点硬質金属被膜の形成を行うようにしたため、機械的性質に優れ、且つ耐摩耗性，耐熱性に優れ、高硬度の金属製品が得られた。

即ち本発明によれば一般鋼の如き表面硬化処理可能な例えばSCM22等の低級材をイオン窒化，浸炭等の手段で表面硬化処理し、この硬化処理層表面に前記によりCr,Mo,W等の高融点硬質金属被膜を形成するようにしたため、硬化処理後の温度管理等で下地金属表面のC原子，N原子が一部熱拡散等を起して被膜素材に浸透等し、これにより

基材と被膜間の密着度を向上させ、又被膜の機械的性質、即ち剥離強度等を向上させ、更にこれにより耐熱性，耐摩耗性に優れた高硬度の被処理物が得られ、従つてバルブロッカーアーム，デフピニオンシャフト等の如く機械摺動部に用いられる金属製品を苛酷な条件下においても充分な耐久性を発揮させることができる。

又本発明によれば、前記に加え、低級材等を用い、表面硬化処理に次いで前記被膜形成処理を併せ行うため、夫々の処理層，被膜は薄くてすみ、このため素材自体の性質を損ねることなく高硬度でありながら靱性，曲げ，捻れ等に極めて強い金属製品が得られ、金属製品の実用性を向上させるとともに、素材も安価なものを用いることができ、且つ表面硬化処理，被膜形成処理も夫々単独で行うのと異り少なくてすみ、従つて前記の如く極めて優れた金属製品を安価に、且つ量産可能に得ることができる等の諸特長を発揮し、実用性に富む。

4.図面の簡単な説明

第1図は本発明にかかる被処理物の一部拡大説

明的断面図、第2図は本発明と従来手段とのテストピース相互の実験結果を説明するためのグラフ、第3図及び第4図は本発明を実施するための装置の一例を示す説明的側断面図である。

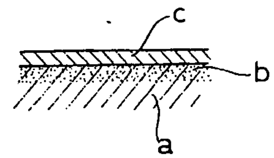
尚図面中aは基材，bは硬化層．cは被膜である。

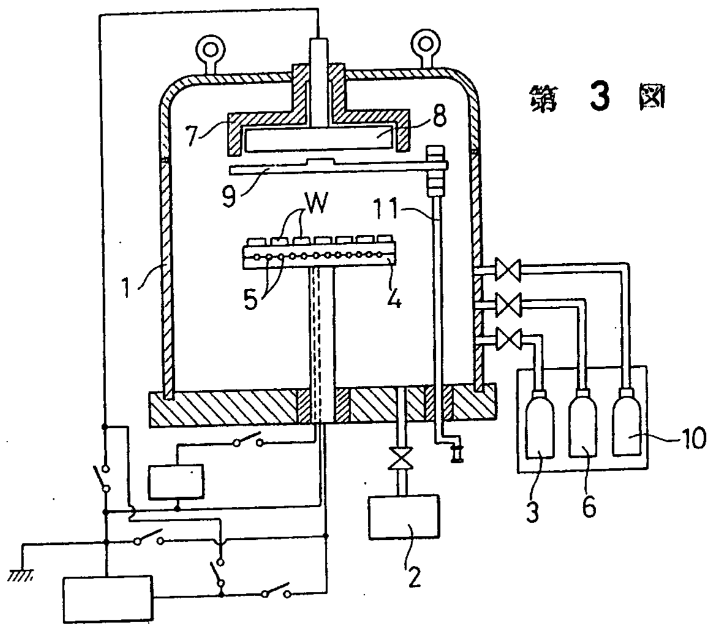
特許出願人　本田技研工業株式会社

代理人弁理士　下田容一郎

同　絹谷信雄

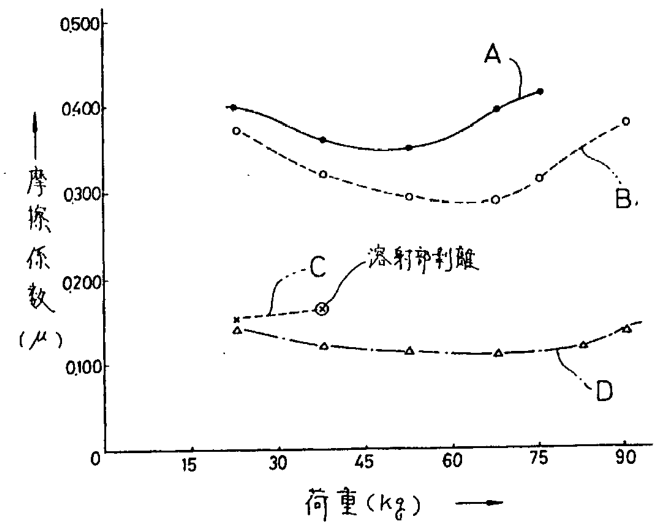
第 1 図



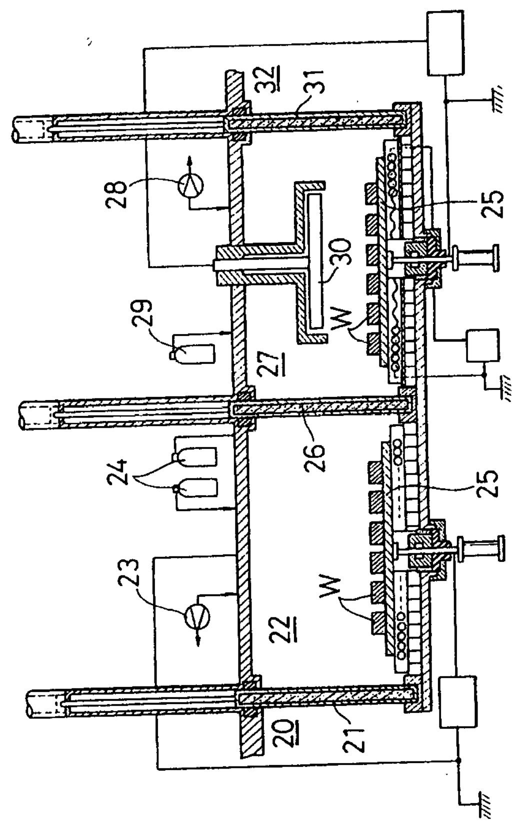


第 3 図

第 2 図



第 4 図



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Japanese Kokai Patent Application
No. Sho 52[1977]-111891

SURFACE PROCESSING METHOD OF METALS

Shigemi Hatakeyama and Shigeku Setani

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SURFACE PROCESSING METHOD OF METALS

[Kinzoku no hyomen shori hoho]

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[There are no amendments to this patent.]

Claim

A surface processing method of metals characterized by forming a hardened layer through a surface hardening process in a surface layer area of a base material consisting of a metallic material that can be processed for surface hardening, and successively forming a metallic coat on the surface of this hardened layer of the base material with a high fusion point hard metal, such as Mo, W, Cr, Ni, TiC, and TiN, for example, by a gas phase surface processing method, such as an ion plating method, sputtering method, or a TiC coating method, for example.

Detailed explanation of the invention

This invention concerns a surface processing method for improving the hardness and the abrasion resistance of a metal through a gas phase surface processing after a surface hardening processing of the metal. It particularly concerns a surface processing method, in which a relatively inexpensive low-grade material that can be processed for surface hardening, such as chromium molybdenum steel and carbon steel for mechanical structures (SCM22, S45C), for example, is used. This is first processed for surface hardening by a carbonitriding method or an ion nitriding method, for example, the surface of this base material then receives a gas phase surface processing by an ion plating method, sputtering method, or a TiC coating method, for example, and a hard metallic product with an improved abrasion resistance is obtained.

With high-speed mechanical sliding parts, such as valve locker arms and dif-pinion shafts, for example, in addition to the requirement of a property such as strength for bending and twisting, satisfaction of severe conditions properties, such as heat resistance or abrasion resistance, for example, is also required.

Accordingly, the following surface processing methods have been conventionally used to conform the aforementioned mechanical parts, for example, to the aforementioned conditions.

More precisely, processing for surface hardening by a method which flame coats a high fusion point metal, such as Mo or W, for example, by plasma flame coating, for example, on the surface of the base material, processing by a method which coats the surface of the base material by hard chrome plating by an electric plating method, and surface hardening processing of the base material by a carbonitriding method or a nitriding hardening method, such as gas soft nitriding, salt bath nitriding, or ion nitriding, for example, have been used.

Regarding such conventional measures, the post-processing is complicated and difficult in the aforementioned flame coating method. Issues occur in the life expectancy of tools and other items. There also is a possibility for the occurrence of separation, and there are issues with separation strength as well. In the aforementioned plating processing method, separation also occurs easily in the boundary area between the base material and the plating layer, the process also requires a relatively long processing time and is not time economically desirable, and an

issue of pollution also exists. General condition performance is sufficient in the surface hardening processing method, however, when a mechanical part that must perform in the severe conditions described above is prepared, it is very difficult to obtain sufficient durability.

While considering the aforementioned present circumstances and issues in the surface processing methods of mechanical parts, for example, that require the severe condition properties such as mechanical strength, heat resistance, or abrasion resistance, for example, described above, the inventors of this invention performed diligent research on the obtainment of metallic products with excellent mechanical strength for bending and twisting, for example, as well as with excellent heat resistance and abrasion resistance, and this invention was completed.

The inventors of this invention have paid attention to gas phase surface processing methods, such as an ion plating method, sputtering method, or a TiC method, for example, have studied several types of said methods for obtaining surface processing through them, have proposed that application to products with a high Hertz stress is difficult when directly coating a high fusion point metal, such as Cr or Mo, for example, on the surface of a low-grade material because the strength of the base material is weak if the hard coating film is not formed thickly, and that they are not suitable for products that become fragile when bending, twisting, and impact, for example, are applied when the coating film is thick, and have gained the knowledge that the level of adhesion between the base material and the coating film increases by giving a surface hardening processing prior to this coating and then giving the aforementioned gas phase surface processing afterwards, so the mechanical performance improves, the heat resistance, abrasion resistance, and the impact resistance, for example, also improve, and a metallic material that can sufficiently withstand severe conditions can be obtained, and through this the invention has been completed.

Accordingly, the objective of this invention is to offer a surface processing method as a surface processing method for mechanical parts, for example, that undergo severe conditions like in mechanical sliding parts, for example, which allows one to obtain a metallic product with excellent mechanical strength for bending and twisting, for example, as well as with an excellent heat resistance, abrasion resistance, and impact resistance and said product sufficiently satisfies the aforementioned conditions.

Another objective of this invention is to offer a surface processing method which uses a base material that can be processed for surface hardening as the base material, such as inexpensive low-grade materials, such as SCM22 and S45C, for example. Accordingly, metallic products that sufficiently satisfy the aforementioned conditions can be obtained using inexpensive base materials, and the aforementioned can be economically mass-produced.

Application examples of this invention will be described in detail along with the figures attached below.

Metallic materials that can be processed for surface hardening are used in the surface processing method in this invention. These materials are acceptable if surface hardening processing is possible. Accordingly, relatively inexpensive low-grade materials, like common surface hardening processing materials, such as SCM22 and S45C, for example, are used. Base material (a) consisting of this material is processed for surface hardening, and hardened layer (b) is formed in the surface layer part. As this surface hardening processing measure, a carbonitriding method, ion nitriding method, salt bath nitriding method, and gas softening nitriding method, for example, are used, and the hardness of the surface layer part of the base material is strengthened, and the base material is strengthened.

Then, a high fusion point hard metal, such as Mo, W, Cr, Ni, TiC, or TiN, for example, is gas phase surface processed onto the base material, to which the surface hardening processing has been given, by an ion plating method, sputtering method, or TiC coating method, for example, an abrasion resisting metallic coating layer (c) is formed on the surface of the hardened layer (b), and a metallic material that withstands the aforementioned severe conditions, such as one with heat resistance and an abrasion resistance, for example, is obtained at the end.

At the formation of this metallic coating layer (c), the surface hardening processing is first given because when a low-grade material is directly coated with a high fusion point hard metal, such as Cr, Mo, or W, for example, the application to products with a high Hertz stress is difficult unless the hard coating layer is formed relatively thickly because the strength of the base material is weak, and the product becomes fragile when the coating increases and is not suitable for products, to which bending, twisting, and impact, for example, are applied. Accordingly, when coating a high fusion point hard metal, such as Cr, Mo, or W, for example, it is necessary to increase the hardness of the base metal beforehand and to then form a hard coating layer on top of it.

In the above, when the hardness of the base metal material (a) is improved through surface hardening processing, such as ion nitriding or carbonitriding, for example, and a high fusion point hard metal, such as Cr, Mo, or W, for example, is coated by a gas phase surface processing method, such as an ion plating method, for example, while maintaining a proper temperature by heating, a very small quantity of C atoms and N atoms on the surface of the base metal penetrate into the coating part on the surface through a heat diffusion reaction, close adhesion between the base material and the coating, such as Cr, Mo, or W, for example, increases, and the mechanical performance of the coating layer improves, and a metallic material that sufficiently withstands severe conditions, such as one with heat resistance, abrasion resistance, and impact resistance, for example, is obtained. With the series of these processing methods, the hardness of the base material in the surface layer part of the base material surface is increased through the surface hardening processing, such as carbonitriding or nitriding, for

example, therefore, the formation of the coating may be thin. A surface hardening processing is given and the aforementioned coating is also formed on the surface. Therefore, the surface hardened layer may also be formed thinly when compared to a type with this alone. As a result, a hard metallic material with excellent heat resistance, abrasion resistance, and impact resistance can be obtained without sacrifice of mechanical properties like tenacity, bending, and twisting, for example, that are possessed by the base material.

The above will be explained in a graph in Figure 2. The graph uses a dif-pinion shaft as the test piece. This is tested using a dry method-increase load, and the results of the measurement are indicated. Each of test pieces A-D has the same conditions and lines A-D in the graph indicate the test pieces. In the graph, the horizontal axis indicates the load in kg, and the vertical axis indicates the coefficient of friction μ. Material S48C (16ø x 100^L) is used as the test piece.

This graph uses a soft nitriding hardening processed material as A, a hard chromium plating processed material as B, a Mo flame-coated material as C, and one that is processed by a soft nitriding hardening as the surface hardening processing method in this invention with Mo coated by a plating method as D. As clearly shown in the graph, A has a large coefficient of friction, and burning occurs when the load is near 75 kg. B has a smaller coefficient of friction than A, but burning occurs when the load is near 90 kg, and C has a small coefficient of friction but the coating layer separates when the load is near 38 kg.

However, the test piece in this invention has a small coefficient of friction as indicated by D, burning does not occur even when the load is near 90 kg, and the aforementioned is proven.

Figures 3 and 4 show examples of concrete systems for the implementation of the surface processing method in this invention. Both indicate methods for giving surface hardening processing through ion nitriding processing and further forming a coating as described above.

Figure 3 shows an application example, in which ion nitriding processing and coat forming processing are simultaneously and continuously obtained within the same furnace, and its details will be explained below. Material to be processed (W) is placed within a furnace (1), the inside is evacuated by a vacuum pump (2), H_2 gas, for example, is introduced by a gas supplying measure (3), for example, and a dc voltage is applied between the metallic material (8) and the support (4) of the material to be processed (W) in this atmosphere, and said material to be processed (W) is heated to near the nitriding processing temperature through ion bombardment. Electricity may also be applied to a heating member (5), which is embedded in the support (4) of the material to be processed (W), and it may be heated in combination with ion bombardment. Next, gases, such as H_2 and N_2, for example, are introduced in at proper proportions by gas supplying measures (3) and (6), and ion nitriding processing is obtained under a gas pressure of 1-10 torr in a specific period of time. During this, the coating metallic material (8), which is supported by an insulating and shielding member (7) at the upper part within the

furnace (1), is covered and protected by a conductive protector (9). This is used as an anode during nitriding processing, and the contamination of the material to be processed (W) and the support (4) during sputtering is prevented.

The aforementioned gas supplying measures (3) and (6) are stopped after the ion nitriding processing, Ar gas is introduced by another measure (10), a voltage is applied to the metallic material (8) in an atmosphere of gas pressure of about 10^{-3} torr, and sputtering welding is performed for a specific period of time. During this, the aforementioned protector (9) is separated from the metallic material (8) by an adjusting bar (11), which supports said protector, and said protector rotates, for example, and is adjusted to a position that does not interfere with the plasma space. The application of electricity to the heating member (5) is also properly adjusted for maintaining the material to be processed (W) at a specific temperature.

In the above, the surface hardening is processed through ion nitriding processing, however, the various types of surface hardening processing methods described above can certainly be used, and a sputtering method, ion plating method, or TiC coating method, for example, as described above can also be properly selected as the gas phase surface processing method after this processing.

Figure 4 shows an application example, in which the aforementioned system is separated as a continuous furnace. Material to be processed (W) is pre-heated in a pre-heating chamber (20) to near the nitriding processing temperature and guided into an ion nitriding processing chamber (22) as a shutter (21) opens, which is deaerated by a vacuum pump (23), H_2 and N_2 gases, for example, are introduced by a supplying measure (24), and the material to be processed (W) over the support (25) receives ion nitriding processing as described above.

Then, the shutter (26) opens, and the material to be processed (W), for which nitriding processing has been completed, is conveyed into a sputtering chamber (27), which is air-tightly sectioned by this shutter (26). The shutter (26) then closes, the inside of the chamber (27) is evacuated using the vacuum pump (28), Ar gas, for example, is introduced by the supplying measure (29), and a voltage is applied to the metallic material (30), and sputtering welding is performed for a specific period of time. The shutter (31) is afterwards opened, and the material to be processed (W) after both processes is sent to a cooling chamber (32). Through this, each processing can be continuously obtained in the processing order, which is convenient for mass production.

The application example above is the same as the aforementioned application example in Figure 3.

In this invention as clearly explained in the explanation above, a metallic material that can be processed for surface hardening is first processed for surface hardening, and a high fusion point hard metallic coat, such as Cr, Mo, or W, for example, is then formed by a gas phase

surface processing method, such as a sputtering method, ion plating method, or a TiC coating method, for example. Therefore, a hard metallic product with excellent mechanical performance as well as with excellent abrasion resistance and heat resistance is obtained.

More precisely, through this invention, a low-grade material, such as SCM22, for example, that can be processed for surface hardening, such as a common steel, for example, is processed for surface hardening by a measure like ion nitriding and carbonitriding, for example, and a high fusion point metallic coat, such as Cr, Mo, or W, for example, is formed by the aforementioned on the surface of this hardening processed layer. Therefore, C atoms and N atoms on the surface of the base material are partially diffused thermally, for example, through maintenance of temperature after hardening processing, and penetrate, for example, into the coat material. Through this, the adhesion between the base material and the coating improves, the mechanical performance of the coating, that is, the separation strength, for example, improves, and a processed hard material with excellent heat resistance and abrasion resistance is obtained. Accordingly, sufficient durability can be displayed in metallic products, such as valve locker arms and dif-pinion shafts, for example, that are used in mechanically sliding parts even under severe conditions.

Through this invention, in addition to the aforementioned, low-grade materials, for example, are used, and the aforementioned coating formation processing is used in combination after the surface hardening processing. Therefore, the respective processing layer and coating may be formed thinly. As a result, a hard metallic product that has strong tenacity against bending or twisting, for example, can be obtained without hurting the characteristics of the material itself. The practicability of metallic products can be improved, and inexpensive materials can also be used. The surface hardening processing and the coat formation processing can be minimized unlike when they are respectively obtained independently. Accordingly, various characteristics are displayed, such as the obtainment of the aforementioned very excellent metallic products at low cost as well as with mass production, and the practicability is great.

Brief description of the figures

Figure 1 is an explanatory cross-sectional illustration of a partially enlarged material to be processed in this invention. Figure 2 is a graph, which explains the experimental results of test pieces of this invention and of conventional measures. Figures 3 and 4 are explanatory side cross-sectional illustrations showing examples of systems in the implementation of this invention.

In the figures, (a) is a base material, (b) is a hardened layer, and (c) is a coating.

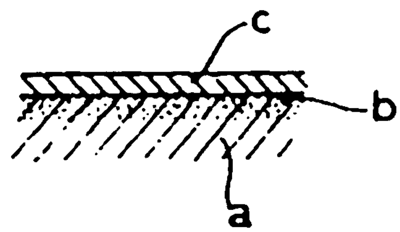

Figure 1

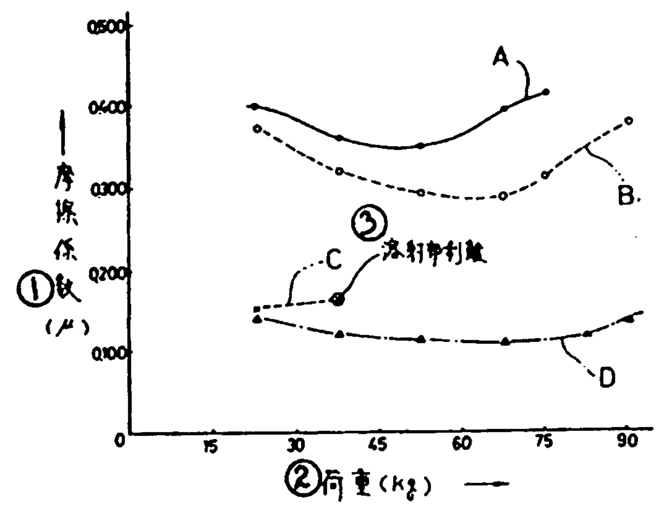

Figure 2

Key: 1 Coefficient of friction (μ)
2 Load (kg)
3 Separation in the flame coating part

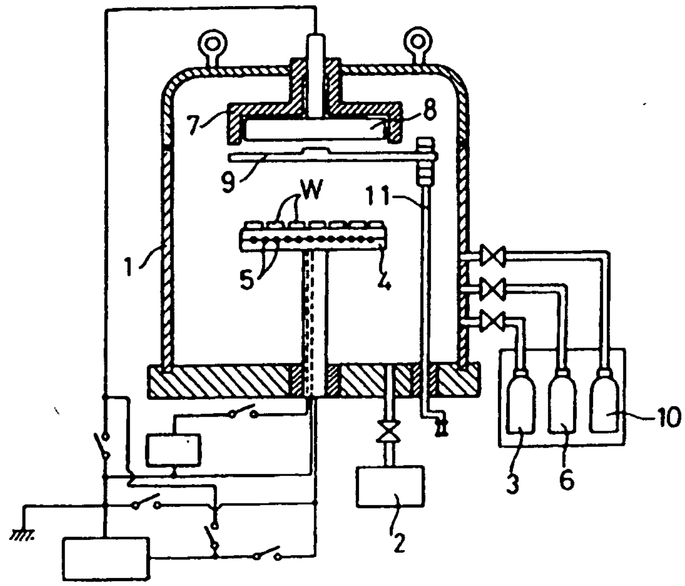

Figure 3

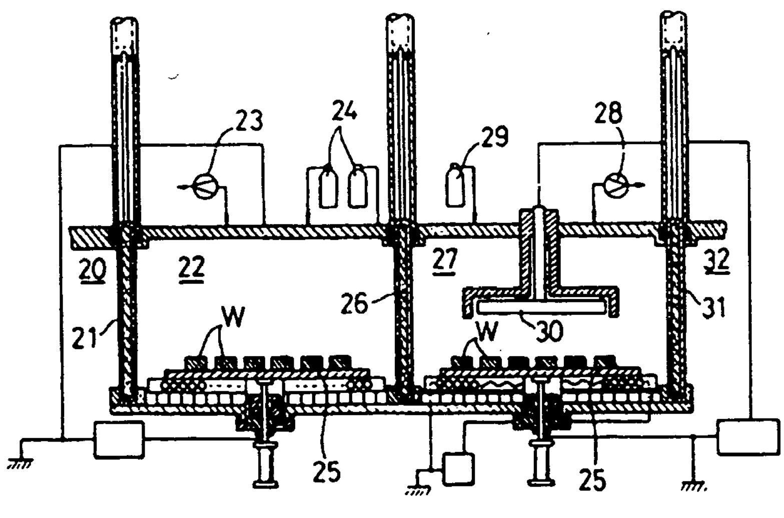

Figure 4